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Calculation for Design of Ropeway Installation Intended for Transportation of Passengers — Code of Practice

ICS 45.100

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Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, MED 06

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, had been approved by the Mechanical Engineering Divisional Council.

An aerial ropeway is a special form of transportation system where passengers/materials are carried on a tensioned wire rope supported above the ground. In ropeways handling passengers, safety, reliability, and conformance to high-quality and good industry practices are paramount for securing the safety of the users. Aerial ropeways are particularly useful in regions where the facility in surmounting natural barriers gives them a great advantage over railways or roads, both of which may need the heavy civil engineering work to secure easy gradient. They are inexpensive to maintain; pollution free; environment friendly; does not affect aesthetics; their power demand is modest; and, they are not seriously affected by adverse climatic conditions.

Nothing in this standard is intended to contravene any provisions of the statutory regulations wherever they are in force.

The composition of the committee responsible for the formulation of this standard is given in Annex B.

This standard proposes to cover calculations for ropeway installation of major components to ensure conformance to the safety and other requirements.

For the purpose of deciding whether a particular requirement of this code is complied with the final value, observed or calculated, expressing the results of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CALCULATION FOR DESIGN OF ROPEWAY INSTALLATION INTENDED FOR TRANSPORTATION OF PASSENGERS — CODE OF PRACTICE

1 SCOPE

1.1 This standard covers the general requirements for calculations for ropeway installation designed for transportation of passengers.

1.2 The scope encompasses design by calculation of major components to ensure conformance to the safety and other requirements stipulated in various ropeway standards listed in Annex A.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in the text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

3 TERMINOLOGY

For the purpose of this standard, definitions given in IS 7649 and the following shall apply.

3.1 Line — Route alignment of the ropeway between two terminals.

3.2 Ropeway Profile — Longitudinal section along Ropeway Route showing location of Terminal station, Intermediate supports and Rope catenary.

3.3 Calculation of Ropeway Profile — Calculations to determine axial forces at different points along the Rope profile and their effects on the intermediate support.

3.4 ChordAngle —Vertical angle of rope between two adjacent supports.

3.5 Angle of Deflection — Angle through which the rope is deflected.

3.6 Rope Gauge —Distance between two Ropes in Horizontal plane.

3.7 Empty Rope — Track rope or hauling rope without carriers.

3.8 Unloaded Rope —Track rope and /or hauling rope only carrying empty carriers at the designed carrier spacing.

3.9 Loaded Rope—Track rope and / or hauling rope carrying fully loaded carriers at the designed carrier spacing.

4 GENERAL REQUIREMENTS

4.1 Calculation Method

4.1.1 Design/Calculation method (manual/ computerized) shall be clearly indicated or explained by proper references

4.1.2 For any calculation, it shall be clear from the presentation, the magnitude and application of all applied loads and their source/origin.

4.1.3 The calculation shall indicate output results for various combinations of loads and determination of worst possible combination.

4.2 Presentation of Calculation

4.2.1 The calculation documents shall be clear, transparent and comprehensible. All documents shall contain easily identifiable number and date.

4.2.2 The results of computer calculations shall be accompanied by a document showing structural models and direction and application of loads and output values (results).

4.3 Broad Spectrum of Calculation

4.3.1 Profile design (with all possible operating conditions) including determination of minimum and maximum tension along the route length.

4.3.2 *Selection of Rope*

4.3.3 Determination of running power for most unfavorable loading condition.

4.3.4 Design/selection of critical mechanical items like Bull Wheels and shafting, Gearbox, couplings, Brakes etc.

4.3.5 Civil foundation design based on the load arising out of different operating condition.

4.3.6 Structural design based on the load arising out of different operating condition.

4.3.7 Electrically interlocked safety devices provided in line and station.

4.3.8 Safety and suitability of Rescue units and devices.

4.4 Calculation Basis

The following shall be taken into account in the calculations:

a) Self weight and imposed loads;
b) Static and dynamic loads;
c) Loads resulting from tension forces in the ropes;
d) Wind and snow loads in accordance with the stipulations given in IS 875;
e) Effect of ambient temperature variation;
f) Loads arising out of avalanches, earthquake, erection condition, etc, in accordance

with the respective Indian standards; and

g) Effect of accumulation of snow on ropes.

4.5 Route and Profile Calculation

4.5.1 The stipulations contained in various ropeway standards listed in Annex A shall be adhered to.

4.5.2 Rope sag between intermediate supports shall be verified for worst loading condition considering:

a) self weight of rope as provided by the manufacturer,
b) static weight of carrier,
c) static weight of passengers as provided in the standards listed in Annex A,
d) calculated rope tension at the point under verification,
e) effect of wind and snow,
f) possible fluctuation during starting and braking, and
g) frictional effect, etc.

   Depending on the normal climatic condition, if the place of installation receives uninterrupted snowfall, effect of accumulation of snow / ice on the ropes shall be taken into account if the snow/ ice deposit cannot be removed in a reasonable time by moving or driving the rope. Unless established data is available, loads may be calculated based on the following inputs:

   1) 20 mm thick accumulation for ropes having diameter 10 mm or less,
   2) 22 mm thick accumulation for ropes having diameter between 11 and 50 mm,
   3) 25 mm thick accumulation for ropes having diameter more than 50 mm, and
   4) Density of snow/ice — 600 kg / m^3.

4.5.3 For continuous movement ropeways having carriers at equal spacing, load from the carriers may be considered uniformly distributed if spacing between carriers is within 50m.Otherwise acting as point load.

The inclination angle at the supports (tangent to the rope curve at the end of span) between the unloaded rope and the loaded rope for continuous movement ropeways, shall not be greater than 8.5° considering the load condition on the other rope spans same as per design.

For installation having a group of carriers which may impose high concentrated load, such angle shall not exceed 13°.

4.6 Determination of Tensile Forces

4.6.1 The following factors shall be considered in determining the tensile forces in ropes:

a) Applied tension;
b) The frictional resistance on the intermediate support shoes/rollers over which the rope moves for most unfavorable loading condition;
c) The frictional resistance of the tension trolley;
d) Travel length of the trolley considering probable elongation in rope; and
e) Type of tensioning device. If hydraulic system is used, effect of probable failure of the system.

4.7 Selection Criterion for Ropes

4.7.1 *Usage*

Track Rope, Carrying-Hauling Rope, Tensioning Rope etc.

4.7.2 Maximum tensile stress at any point on line considering dynamic effect during starting and braking.

4.7.3 Safety factor as stipulated in respective ropeway standards listed in Annex A.

4.7.4 Ambient condition at the place of installation.

4.7.5 In addition, stipulations laid in IS 5230 and IS 17232 for Track Ropes and IS 5228, IS 5229, IS 16620 and IS 16623 for haulage ropes shall be considered.

4.7.6 Elastic Modulus of Rope shall be considered as per manufacturer’s recommendation for the particular application and the operating condition

4.8 Calculation for Ropeway Drive Unit

4.8.1 Drive Power shall be determined from the transmission of tangential forces to the drive sheave, which, in turn, shall depend on the frictional coefficient of sheave or liner materials.

Drive power determination shall be in accordance with the following equation:

$$\text{Driving force} = T_1 - T_2 \text{ and}$$

$$T_1 / T_2 = e^{\mu\Theta}$$

Where:

T_1 = maximum tangential force or tension,
T_2 = minimum tangential force or tension,
e = base of the logarithm = 2.71828,
μ = coefficient of friction, and
Θ = angle of contact with the drive sheave – in radians.

The following Co-efficient of friction shall be considered for different materials

a)	Rubber-lined rollers	3.0 percent
b)	Plastic-lined rollers	2.0 percent
c)	Sheaves with roller bearings	0.3 percent
d)	Sheaves with journal bearings	1.0 percent
e)	Ropes on track rope shoes	10.0 percent
f)	Track rope roller chains with roller bearings	0.5 percent
g)	Track rope roller chains with journal bearings	1.0 percent
h)	Steel wheels on carriers for funicular railways without eccentric haul rope connection	1.0 percent
j)	Steel wheels on carriers for funicular railways in the case of horizontal bends or eccentric haul rope connection	2.0 percent
k)	Pneumatic tyres on carriers for funicular railways on concrete *or* steel girders without eccentric haul rope connection	1.5 percent
m)	Pneumatic tyres on carriers for funicular railways in the case of horizontal bends or eccentric haul rope connection	2.5 percent
n)	Carrier truck rollers on aerial ropeway carriers	2.0 percent
p)	Steel rollers on steel surfaces	1.0 percent
q)	Skis on ski-tow tow-tracks	10.0 percent

4.8.2 Drive power shall be calculated for worst combination of loading cases generally as below:

a) Load carriers up, empty carriers down;
b) Empty carriers up, load carriers down; and
c) Line fully complemented with loaded carriers on both sides.

4.8.3 For all other design consideration, the stipulation contained in IS 17239 and ropeway standards listed in Annex A shall be followed.

4.8.4 Following characteristics shall also adhered to the respective ropeway standards as indicated in Annex A.

a) Vertical clearance i.e. maximum height of the lowest portion of the vehicle from the ground measured in most unfavorable condition;
b) Mass of a person;
c) Rope Guiding;
d) Maximum load exerted by the carrying hauling rope;
e) Traverse loads and pulley diameter;
f) Loads on sheave, drums and saddles; and
g) Speed of the ropeway.

However, for self-weight of rope and carrier, this shall conform to manufacturer's recommendations/brochure/information.

4.9 Criterion for Structural Design

4.9.1 The loads to be considered on ropeway structures, their application and safety parameters have been specified in respective ropeway standards listed in Annex A.

4.9.2 Considering the possibility of rope being removed from its mounts on one side, the supporting towers shall be designed considering worst loading on one side and no load from rope and carriers on the other side.

4.10 Calculation for Civil Engineering Works

4.10.1 Various criteria, guide lines and references stipulated in IS 17237 civil engineering works shall be followed.

ANNEX A

(*Clauses* 2, 4.5.1, 4.5.2, 4.7.3 *and* 4.8.3)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
5228 : 2017	Continuous movement monocable ropeways with fixed grips intended for transportation of passengers — Code of practice for construction
5229 : 2017	Aerial ropeways —Transportation of passengers — Continuous movement monocable with automatic grips — Construction and design — Code of practice
5230 : 2017	Continuous to and fro movement bi-cable ropeways intended for the transportation of passengers — Code of practice for the construction
7649 : 1975	Glossary of terms used in connection with aerial ropeways
16620 : 2017	Jig back movement monocable ropeways with fixed grips — Code of practice
16623 : 2017	Pulsated movement Monocable Ropeways with Fixed grips — Code of practice
17232 : 2019	Continuous movement Bicable / Tricable Ropeways with Detachable Grip — Code of practice
17237 : 2019	Code of practice for design and construction of civil engineering works for ropeways — General requirements
17239 : 2019	Safety requirements for drives used for ropeway installation for passenger transportation

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Composition of Continuous Bulk Conveying, Elevating, Hoisting, Aerial, Ropeways and Related Equipment Sectional Committee, MED 06

Organization	*Representative(s)*
RITES Limited, Gurugram (Haryana)	Shri Rajiv Mahajan (***Chairman***)
Central Institute of Mining and Fuel Research (CIMFR), Dhanbad	Shri Debasis Basak Shri Girendra M. Prasad (*Alternate*)
Conveyor Ropeway Services Pvt Ltd Kolkata	Shri S. Shekhar Chakravarty Shri Kamal Kumar Bose (*Alternate*)
Damodar Ropeways and Infra Limited, Kolkata	Shri D. L. Das
DESEIN Private Limited, New Delhi	Shri H. K. Gupta Shri Arvinder Singh (*Alternate*)
Directorate General of Mines Safety, Dhanbad	Shri D. B. Naik Shri Vijay Kumar K. (*Alternate*)
Directorate General Factory Advice Service and Labour Institutes, Mumbai (DGFASLI)	Shri Sumit Roy Shri H. M. Bhandari (*Alternate*)
ELECON Engineering Co Ltd VallabhVidyanagar	Shri C. S. Shah Shri K. S. Kodia (*Alternate*)
Indian Association of Amusement Parks and Industry, New Delhi	Shri Pradeep Sharma Shri Balwant Chawla (*Alternate*)
Mcnally Bharat Engineering Co Ltd Kolkata	Shri Sujoy Maiti Shri Sandipan Daw (*Alternate*)
Mecon Limited, Ranchi	Shri Sanjoy Bhattacharya Shri Amit Pal (*Alternate*)
Ministry of Shipping, New Delhi	Shri B. Poiyaamozhi Shri D. J. Basu (*Alternate*)
National Mineral Development Corporation Ltd Hyderabad	Shri Alok Mehta Shri S. Surender (*Alternate*)
National Thermal Power Corporation Ltd New Delhi	Shri O. P. Kalia Shri B. K. Bhattacharya (*Alternate*)
Phoenix Conveyor Belt India (P) Ltd, New Delhi	Shri Rajeev Sharma Shri Asoke Kumar Ghosh (*Alternate*)
Polo Amusement Park Ltd, Gurugram	Shri Santosh Chawla
Projects And Development India Limited, Dhanbad	Shri Narendra Singh
RITES Ltd, Gurugram	Shri N. C. Srivastava
Ropeway and Resorts Pvt Ltd, Kolkata	Shri A. K. Kinra
Steel Authority of India Ltd (IPSS Sect), CET Ranchi	Shri Sanjay Kumar Shri Deepak Biswal (*Alternate*)
TRF Limited, Jamshedpur	Shri N. K. Singh Shri Subhash Sharma (*Alternate*)
Usha Breco Limited; Ghaziabad	Shri Manoj Panwar Shri Sanjeev Dhariwal (*Alternate*)
Usha Martin Limited, Ranchi, Jharkhand	Shri Subrata Dutta Shri Sandeep Jaiswal (*Alternate*)

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Member Secretary
A. K. Mohindroo
Scientist 'C' (MED), BIS

Composition of Panel 1 On 'Aerial Ropeways', MED 06

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